# Wave–Particle Duality in Resonant Mechanics


## Abstract

In Resonant Mechanics, a quantum is a coherence: a stable boundary code (Form) borne by a living substrate composed of a stored-potential Field and its helicity-driven Flow. The apparent duality arises from two stages of one process. During propagation, a coherence rides as a distributed carrier phase (the "wave"), guided by laminar, bi-helical corridors. At arrival, the same coherence rewrites a receptive boundary (detector, atom, lattice site) in a quantized step (the "particle"). Interference reflects how phase distributes acceptance across alternatives; localization reflects the single site that completes the code update. Measurement corresponds to membrane engineering that controls which phases may recombine, while entanglement is a shared boundary code maintained by twin-handed carriers enforcing helicity neutrality. Thus, wave–particle duality is not two kinds of stuff but two roles of the same coherence—propagation as phase; detection as boundary recoding.


## 1. Substrate and Postulates

**Form (boundary code):** The information that stabilizes a structure on a thin interface (nuclei, orbitals, resonators, pixels).
**Field (stored potential):** The energy reservoir whose twist (helicity) accounts for available orderly work.
**Flow (actuation):** Gyroscopic/cycloidal motion that releases Field potential along bi-helical, low-shear corridors (two natural circular modes).

Postulates:

1. A quantum is a coherence: Form carried by phase on the Field/Flow substrate.
2. Domain membranes maintain phase separation and orthogonality between alternatives.
3. Helicity neutrality is maintained by issuing phase work in conjugate pairs (± handedness).

## 2. The "Wave": Distributed Carrier Phase

**Carrier reality:** Propagation proceeds as phase-coherent carriers—two circular (handed) modes traveling in laminar lanes. The coherence's energy–momentum budget sets the spacing of phase fronts (wave-like behavior).
**Guidance by boundaries:** Slits, mirrors, cavities, and lattices act as phase shapers, redirecting carriers and establishing standing/traveling patterns.
**Interference as acceptance geometry:** Overlap of carriers determines where a downstream boundary is most "ready" to accept the code update; the resulting intensity pattern is the map of acceptance, not an energy spray.

## 3. The "Particle": Boundary Recoding

**Discrete arrival:** Detection is a code update of a local boundary (an atomic transition, a detector pixel flip). Because stable boundaries admit only specific updates, the transfer is quantized.

**Single-click logic:** Many sites may be phase-eligible, but once one site accepts, the global code closes and all other candidates lose eligibility—hence one event per quantum.

No hidden corpuscle required. The “particle” is the act, not a bead traveling inside the wave.

## 4. Double-Slit Phenomenology

**Both slits open; no tagging:** Carriers traverse both corridors; phases recombine at the screen; acceptance follows the interference map. Single events are discrete, but the aggregate pattern is wave-like.
**Which-path marking:** Polarizers, scatterers, or timing marks insert membranes that destroy phase orthogonality between paths; recombination fails; fringes vanish.
**Delayed choice:** Changing the membrane before boundary lock-in changes recombination permission, not the past. Carriers retain phase memory until a boundary accepts.

## 5. Quantization from Boundary Codes

**Allowed updates only:** Atoms, cavities, and lattices accept specific code steps that preserve stability.
**Canonical effects:** Photoelectric and Compton phenomena reflect the minimum phase-work needed to flip the boundary to a new code; the discreteness is the signature of the boundary, not a pellet-like projectile.

## 6. Measurement as Membrane Engineering

**Membranes control mode freedom:** A measurement device is a phase-selective membrane that forces the coherence into one lane or one basis (path, polarization, spin).
**Weak measurement:** “Thin” or leaky membranes only partly disturb phase, leaving reduced interference rather than abolishing it.
**Classical limit (decoherence):** Dense environments behave as random membranes, scrambling phase relations so acceptance averages become classical probabilities.

## 7. Entanglement as Shared Code

**Shared boundary:** Entangled quanta share a single boundary code distributed over distance by twin-handed carriers.
**Outcome correlations:** When one side accepts an update, the shared code re-phases as a whole, producing strong correlations without controllable signaling.
**Helicity bookkeeping:** Opposite-handed carriers keep the helicity ledger neutral across the pair.

## 8. Tunneling and Phase-Enabled Access

Barrier crossing. A barrier that is classically prohibitive may still admit a phase-compatible update if carriers maintain coherence across it. Tunneling is acceptance via phase continuity, not secret passage by a hidden particle.

## 9. Aharonov–Bohm–type Phase Shifts (Substrate View)

Potential as phase sculptor. Vector and scalar potentials reshape carrier phase even where forces vanish, altering acceptance geometry downstream. In Resonant Mechanics, the substrate stores these phase edits in the Field, which the boundary then reads out.

## 10. Conceptual Implications

**Duality resolved:** A single entity behaves wave-like while exploring acceptance through phase and particle-like when committing to a boundary update.
**Measurement clarified:** Outcomes track which membranes we impose; change the membrane, change which phases can recombine—hence change patterns without retrocausality.
**Unification of mysteries:** Interference, quantization, tunneling, entanglement, and potential-induced phase shifts are different faces of one substrate fact: boundaries admit code updates only when phase, geometry, and helicity balance align.

## Conclusion

Wave–particle duality in Resonant Mechanics is the natural behavior of a coherence moving and arriving in a living substrate. The wave is the distributed phase that guides where a boundary could accept; the particle is the discrete update a boundary does accept. Membranes, helicity balance, and boundary codes determine how possibilities are sculpted into a single event. There is no paradox to resolve—only a process to recognize: propagation as phase, detection as recoding.